4. Interference Evaluation Methodologies to be Applied in Evaluating MSS Downlink Interference into FS Receive Stations

Diagrams describing the interference evaluation methodologies to be used in evaluating the impact of MSS downlink interference into analog and non-ATPC digital[7] FS receive stations are shown in Figures 4-1a and 4-1b. The roadmap identifies the three "areas" that comprise the overall evaluation methodology and the applicable sections in this TSB: (1) inputs; (2) analysis and (3) comparison.

There are two "simple" analysis methods to apply in order to determine whether or not there is a need to perform more detailed interference calculations. For analog FS links the simple method is referred to as a Power Flux Density (PFD) calculation, and for digital FS links the simple method is referred to as a Fractional Degradation of Performance (FDP) calculation; both are identified in boxes at the top of Figures 4-1a and 4-1b. These simpler, initial analysis methods are the same as those used internationally to determine the need to coordinate MSS networks with FS assignments in the 2 GHz frequency bands, and they are described in the ITU Radio Regulations Appendix S5 and Recommendation ITU-R IS.1143.

As noted in Figure 4-1b for digital systems, the FDP calculation is performed in two, distinct stages. In the first stage, *representative* FS system parameters from ITU-R IS.1143 are used to evaluate whether or not the FDP criteria of RR Appendix S5 are met. For those cases in which the FDP criteria are not met, the FDP calculation is repeated in a second stage, this time using the *actual* FS system parameters.

If the PFD criteria are not met for FS analog links using *representative* FS system parameters, then a more detailed interference analysis is necessary. The initial detailed calculations involve MSS-only calculations as shown on Figure 4-1a. As noted in that figure, the MSS-only calculation is performed in two distinct stages similar to the FDP calculation described above. In the first stage, *representative* FS system parameters from RR Appendix S5 are used to evaluate whether or not the MSS-only criteria of Section 3.2.1.1 are met. For those cases in which the MSS-only criteria of Section 3.2.1.1 are not met, the MSS-only calculation is repeated in a second stage, this time using the actual FS system parameters.

As shown in Figures 4-1a and 4-1b for both FS analog and digital links, respectively, the next analysis stage, if required, is to perform one of two detailed analyses which are applicable for "aggregate noise

[7] It is important to note that the number of digital radios operating under ATPC conditions can be significant. As shown in Table 2-2 (Section 2.2.2), approximately 10% of the radios in service are Tadiran radios which only operate under ATPC regardless of whether or not they are coordinated this way. Approximately 17% of the radios in service are Alcatel radios which have ATPC capability built-in; and, *may* be operating under ATPC regardless of whether or not they are coordinated this way.

power" calculations. These two analytical methods are referred to as the *convolution approach* and the *Monte Carlo approach*.

The *convolution approach* is a combination simulation and analysis approach. It involves simulation of the MSS space segment in order to determine probability density function (PDF) data for the received MSS interfering signal power as a function of azimuth angle and antenna size. The link performance is then calculated analytically using a convolution to account for the variation in MSS receive interference power and multi-path fading. The *Monte Carlo approach* involves a full simulation to characterize both the MSS space segment and multi-path fading. Both approaches should result in equivalent performance data; however, the *convolution approach* precludes the need for developing a Monte Carlo-type simulation to address multi-path fading and the resulting computer processing time required to run the Monte Carlo simulation.

The FS link performance data generated via the above detailed methods are then compared to the appropriate "aggregate noise power" criteria described in Section 3.1.2.1 (analog links) or 3.2.2 (digital links). If the interference criteria are met, the evaluation is complete. If the evaluation criteria are not met, further analysis and/or negotiation is required.

The input, analysis and comparison areas identified in Figures 4-1a and 4-1b are more fully discussed below.

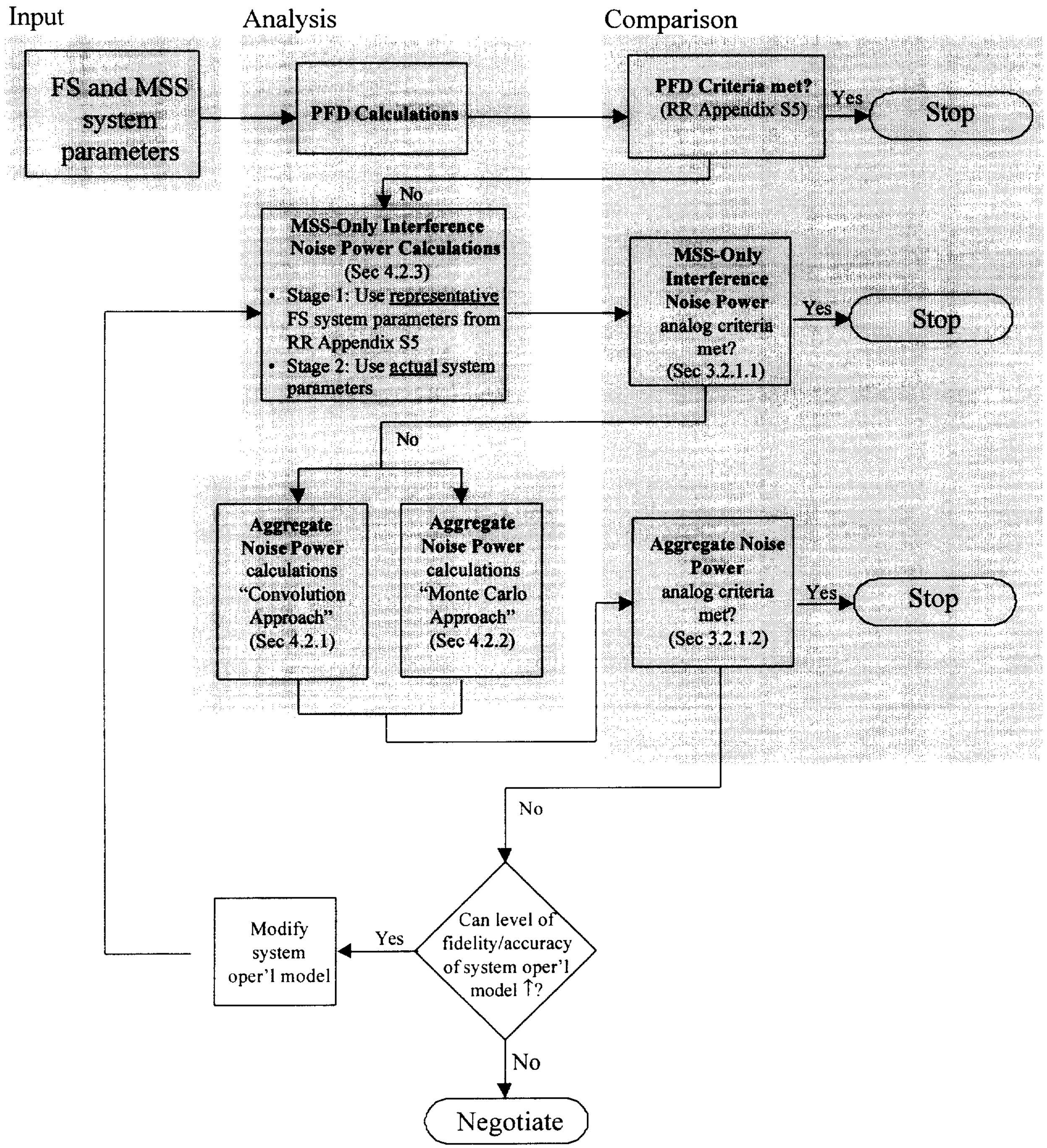

Figure 4-1a: Road Map of the MSS/FS Interference Evaluation Methodologies for Analog Links

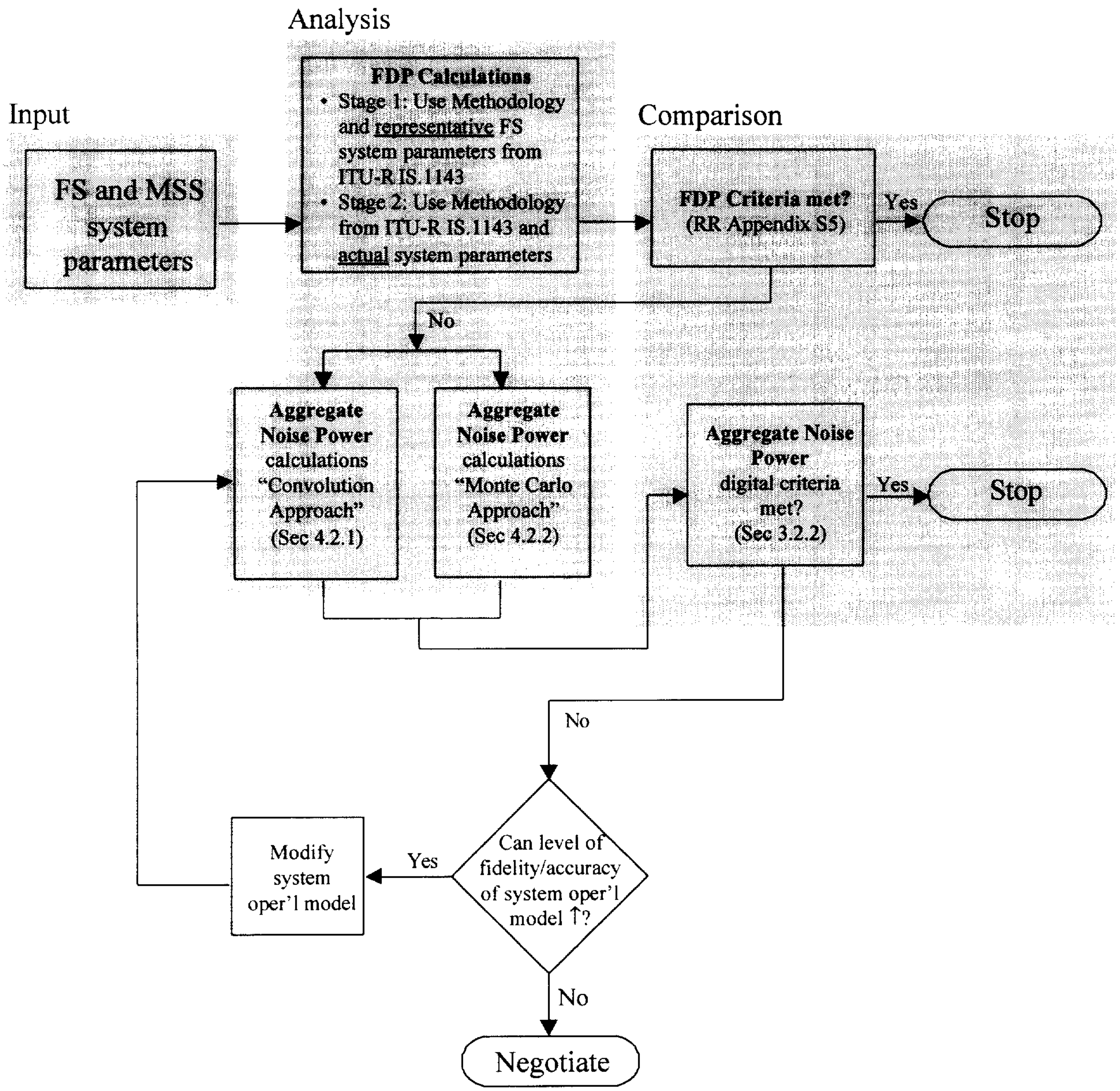

Figure 4-1b: Road Map of the MSS/FS Interference Evaluation Methodologies for Digital Links

4.1 Analysis Inputs

The interference evaluation methodology to be used in assessing the potential impact of MSS downlink interference into FS receive stations requires input data characterizing various aspects of both the MSS systems and the FS system being coordinated.

FS System The required FS system input data includes the path design parameters. Examples of these items include receiving antenna heights, gains, and gain pattern characteristics, receiver equipment characteristics, terminal location, path length and azimuth angle, operating frequency, etc. These parameters may be obtained from the FS system providers, equipment vendors and/or existing FS microwave databases. Annex H includes a list of the required FS system parameters.

Note that the actual or predicted FS antenna patterns and equipment characteristics must be used whenever possible. In the absence of actual or predicted antenna patterns, the reference antenna pattern in Recommendation ITU-R F.1245, Recommendation ITU-R F.699, or Annex B should be used. (Note: Annex B also includes an adjustment for different antenna polarization schemes for MSS satellite systems and FS receive systems.)

MSS System

The required MSS system input data includes information characterizing the MSS space segment and certain system operational parameters.

Data characterizing the levels of MSS interference power is needed that accounts for the receive antenna pattern, azimuth angle and latitude/longitude, of the FS receiver being considered. For digital FS links, the MSS interference power is calculated over the RF bandwidth of the FS receiver, whereas for analog FS links the MSS interference power is calculated over the 4-kHz bandwidth of the channel being investigated. This data is commonly expressed in the form of a probability density function (PDF).

For the *convolution approach* analysis method described in Section 4.2.1, the PDF of the MSS interference power will either be provided directly by the MSS system operators or it will be generated using the MSS system orbital characteristics, the MSS traffic model, FS receiver antenna and equipment characteristics, etc. For the *Monte Carlo approach* analysis method described in Section 4.2.2, the PDF of the MSS interference power are generated and applied internally as a part of the overall simulation.
Annex H includes a list of the required MSS system parameters. Modifications to the MSS input parameters may result in the need for re-coordination (i.e., if the potential levels of interference are increased). Note that the actual or predicted FS antenna patterns should be used whenever possible. In the absence of actual or predicted antenna patterns, the reference antenna pattern in Recommendation ITU-R F.1245, Recommendation ITU-R F.699, or Annex B should be used. The methods described in Recommendation ITU-R F.1108, or similar methods, should be used to determine the visibility statistics of MSS space stations as seen by a terrestrial FS receiver station. The method of Recommendation ITU-RF.1108 has been included in Annex E.

4.2 Analysis Area

As previously stated, there are three primary analysis methods presented in this TSB: (1) Aggregate noise: Convolution Approach, (2) Aggregate noise: Monte Carlo Approach, and (3) MSS-only

Interference Noise Power. The details for each of these analysis methods are presented in sections 4.2.1, 4.2.2, and 4.2.3, respectively.

4.2.1 Aggregate Noise Power: Convolution Approach

The *convolution approach* analysis method to be used in evaluating FS link performance in the presence of MSS downlink interference on an "aggregate noise" basis comprises the three steps described below.

4.2.1.1 Step 1: Quantify Baseline FS Link Performance without MSS Interference

In this step, the baseline FS link performance is quantified in a multipath fading environment without the presence of MSS interference. An equation is derived that generates the probability that a given fade value, in dB, exceeds the link margin.

In general, we want to calculate the probability that the received signal-to-noise ratio (SNR) for a given link[8] is less than the required SNR:

$$P\{SNR_{rcv} < SNR_{req}\} \qquad 4\text{-}1$$

SNR_{req} represents the signal-to-noise ratio required at the receiver on a given link to ensure a desired level of performance. SNR_{rcv} is a random variable that represents the actual received signal-to-noise ratio at the receiver, taking into consideration random multi-path fading. Its value is derived as follows:

$$SNR_{rcv} = \frac{SNR_{link}}{A} = \frac{C/N}{A} = \frac{P_t G_t G_r / NL_p}{A} \qquad 4\text{-}2$$

where:

---

[8] For the purposes of this analysis, the terms "path" and "link" are used interchangeably. There is no difference in the meaning of the terms. However, it is noted that in the engineering literature, the power margin above a specific SNR threshold on a specific microwave link or path is usually referred to as "link margin" rather than "path margin." Nevertheless, is convenient to use both terms throughout the discussion within TSB-86.

C/N	=	Carrier-to-Noise power ratio (unitless)
N	=	Noise Power (Watts)
P_t	=	Transmit Power (Watts)
G_t	=	Transmit Gain (unitless)
G_r	=	Receive Gain (unitless)
L_p	=	Path Loss (unitless)
A	=	A variable that represents the link fade depth (expressed as a unitless factor)

and SNR_{link} represents the ideal signal-to-noise ratio at the receiver in benign conditions (i.e., without fading taken into account). Substituting the results of Equation 4-2 into Equation 4-1 we obtain:

$$P\{SNR_{rcv} < SNR_{req}\} = P\left\{A > \frac{SNR_{link}}{SNR_{req}}\right\} \qquad \text{4- 3}$$

If we define the following:

A_{dB}	=	A variable that represents the link fade depth (expressed in dB)
$SNR_{rcv,dB}$	=	SNR_{rcv} in dB
$SNR_{req,dB}$	=	SNR_{req} in dB
$SNR_{link,dB}$	=	SNR_{link} in dB

we can write:

$$P\{SNR_{rcv,dB} < SNR_{req,dB}\} = P\{A_{dB} > M_{dB}\} \qquad \text{4- 4}$$

$$\cdot \; p_w(M_{dB})$$

where M_{dB} is the link margin, in dB, and it is simply the difference between the link SNR and the required SNR, both in dB (i.e., M_{dB} is equal to $SNR_{link,dB} - SNR_{req,dB}$).

Equation 4-4 above states that the probability that the received SNR is less than the required SNR, both measured in dB, is equal to the probability that the fade experienced on the link, A_{dB}, is greater than the link margin, M_{dB}, with both measured in dB. We define this latter probability as the function,

p_w, and note that it is dependent upon M_{dB}. The importance of this observation will become apparent in the following section, where MSS interference is considered. The expressions derived in ITU-R P.530 should be used to quantify Equation 4-4 above.

4.2.1.2 Step 2: Transform the PDF of the MSS Interference Power at the FS Receiver into PDF data for a Newly Defined Variable

In this step, the PDF of the MSS interference power at the FS receiver is transformed into the PDF of a different variable required by the analysis in step 3 below. It will be assumed that the PDF of the MSS interference power into the FS receiver as a function of azimuth and antenna size is available as an input, either directly from the MSS system operator or by generating it via simulation using the appropriate MSS system characteristics. It is noted that the MSS interference power seen at the FS receiver is a variable that can be expressed either in Watts or in dBW, and the following two variables are defined to represent the MSS interference power for each case:

I = A variable that represents the level of interfering signal power, in Watts, arriving from the mobile satellite system (MSS) at the input to the fixed service (FS) receiver

I_{dBW} = A variable that represents the level of interfering signal power, in dBW, arriving from the mobile satellite system (MSS) at the input to the fixed service (FS) receiver

The PDF of I can be easily derived from the PDF of I_{dBW} and vice versa.

In order to facilitate the calculations in step 3 below, two new variables, I'' and I''_{dB}, are defined as follows:

I'' = A variable that represents the amount that the MSS interference power plus the FS noise power exceeds the noise floor, N, at the input to the FS receiver (expressed as a linear power ratio)

I''_{dB} = A variable that represents the amount that the MSS interference power plus the FS noise power exceeds the noise floor, N, at the input to the FS receiver (expressed in dB). I'' can be considered to be the threshold degradation (or "fade margin loss" in ITU-R Study Group 9 Recommendations), where the relationship between the variables I'' and I is:

$$I'' = \frac{N + I}{N} \qquad 4\text{-}5$$

and the relationship between the variables I''_{dB} and I_{dBW} is:

$$I''_{dB} = 10\log \frac{10^{\left(\frac{I_{dBW}}{10}\right)} + N}{N} \qquad 4\text{-}6$$

N is the value of the noise floor at the input to the FS receiver expressed in Watts. PDF data for the variable I''_{dB} defined above is needed for step 3 of the MSS/FS interference evaluation methodology. Thus, a transformation is required between the available PDF data of the variable I_{dBW} and the variable I''_{dB}.[9] Annex I provides the derivation of the required transformation. The resulting transformation is as follows:

$$f_{I''_{dB}}(i''_{dB}) \quad \frac{f_{I_{dBW}}(i_{dBW} = i_{1,dBW})}{\left|g'(i_{1,dBW})\right|}$$

$$\frac{f_{I_{dBW}} \quad i_{dBW} \quad 10\log \quad N10^{\frac{i''_{dB}}{10}} \quad N}{1 \quad 10^{\frac{-i''_{dB}}{10}}} \qquad ;\ i''_{dB} \quad 0\,dB \qquad 4\text{-}7$$

$$0 \qquad ;\ i''_{dB} \quad 0\,dB$$

where, in general, $f_X(x)$ represents the PDF of the variable X evaluated at X=x.

---

9 It should be noted that PDF data for the variable I'' can be generated directly via simulation. In this case, the transformation in Step 2 of the methodology is not needed.

As shown in Equation 4-7, the transformation results in a scaling factor and a non-linear shift along the x-axis. Thus, using Equation 4-7 above, it is straightforward to generate PDF data for the variable I''_{dB} using the available PDF data of the MSS interference power.

4.2.1.3 Step 3: Quantify FS Link Performance with MSS Interference

The next step is to quantify the FS link performance in the presence of both random fades and MSS downlink interference. We take the same approach as applied in step 1 above. That is, the probability that the received SNR is less than the required SNR is determined. However, in this case, we take into consideration both random multi-path fading and MSS interference. Thus, Equation 4-2 is re-written as follows:

$$SNR_{rcv} = \frac{C/(N+I)}{A} = \frac{\left(P_t G_t G_r / (N+I)L_p\right)}{A} \qquad 4\text{-}8$$

where the variable I was defined above. Substituting the results of Equations 4-5 and 4-8 into Equation 4-1, and applying the definitions of the variables A_{dB}, I''_{dB}, and M_{dB}, provided previously, the following equation can be derived:

$$P\{SNR_{rcv,dB} < SNR_{req,dB}\} = P\{A_{dB} > M_{dB} - I''_{dB}\} \qquad 4\text{-}9$$

Although Equation 4-9 is quite similar in appearance to Equation 4-4, the analysis and methodology provided in ITU-R P.530 to calculate the probability that the receive SNR is less than the required SNR is not directly applicable to our situation since both A_{dB} and I''_{dB} are variables. An expression to calculate the above probability has been separately derived resulting in the following:

$$P\{SNR_{rcv,dB} \quad SNR_{req,dB}\} \quad p_w \quad f_{I''_{dB}} \quad \int_0^{\infty} p_w(M_{dB} \quad i''_{dB}) f_{I''_{dB}}(i''_{dB}) di''_{dB} \qquad 4\text{-}10$$

We note that $f_{I''db}$ is the PDF of the variable I''_{dB}. Furthermore, p_w is precisely the expression calculated in ITU_R P.530 to determine the probability of the link fade, A_{db}, exceeding some value, in this case $(M_{dB} - i''_{dB})$, where i''_{dB} represents the range of values that the variable I''_{dB} can assume.

Thus, step 3 of the MSS/FS interference analysis involves convolving the link fade probability function, p_w , with the probability density function of the variable I''_{dB}. This convolution results in the probability that the received SNR is less than the required SNR (i.e., the link fails) for a given link that is experiencing both random multi-path fading and a random MSS interference signal. The expressions given in ITU-R P.530 are used to generate the p_w data and the transformation shown in step 2 above is used to generate the PDF of I''_{dB} using the available PDF data of the MSS interference power.

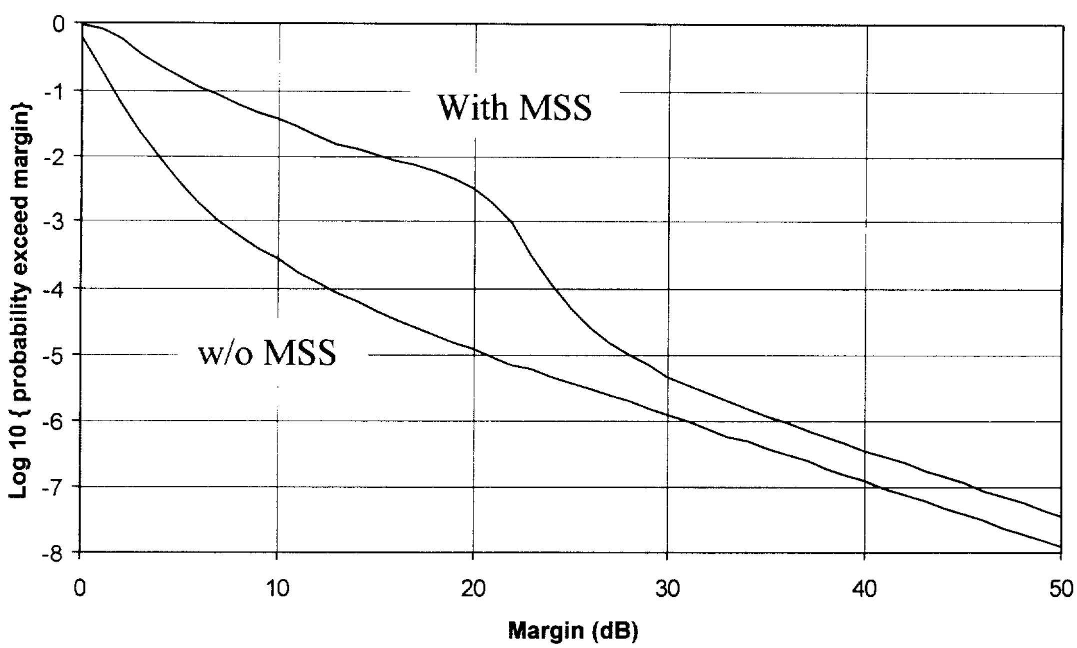

Figure 4-2: Representative Plot Depicting the Performance Results of Steps 1 through 3 of the Convolutional Approach

4.2.1.4 Step 4: Interpret the Performance Results Within the Context of the MSS Downlink Interference Criteria of Section 3

As stated above, the performance data generated using the *convolutional approach* analysis method is a plot of the probability that a link will be unavailable (i.e., link unavailability) as a function of the link margin. The MSS downlink interference criteria provided in Section 3 are given in terms of unavailability limits for digital links and baseband noise power criteria for analog links. Thus, the method for interpreting the above performance results is different depending upon the modulation of the FS link being evaluated. The following sections separately address the specific procedure to be applied in interpreting the performance data generated by the *convolutional approach* analysis method for digital and analog FS links, respectively.

Digital Links - It is straightforward to interpret the performance data generated by the *convolutional approach* analysis method for digital links since the MSS downlink interference criteria are given in Section 3.2.2 in terms of link unavailability. The procedure is as follows:

1. Calculate the Link Margin in dB.

$$M_{dB} = RSL_{dBm} - RCVR\ Threshold_{dBm} \qquad 4\text{-}11$$

   where RSL_{dBm} is the theoretical received signal level at the input to the FS receiver in dBm and $RCVR\ Threshold_{dBm}$ is the FS receiver threshold value in dBm.

2. Determine the inherent (Pre-MSS) Link Unavailability (i.e., the FS link unavailability achieved without MSS interference) using the performance data generated by the *convolutional approach* analysis method, represented in Figure 4-2 above, at the link margin calculated using Equation 4-11 above.

3. Determine the MSS interference criteria region (i.e., *Simple Unavailability Region* or *Performance Degradation Region* from Figure 3-3 in Section 3.2.2) using the Pre-MSS Link Unavailability and Link Margin calculated above, along with the *Simple Unavailability Limit* and the *Performance Degradation Limit* provided in Section 3.2.2.

4. Determine the MSS Downlink Interference Criteria using the results from #3 above along with Figure 3-3 of Section 3.2.2.

5. Determine the Post-MSS Link Unavailability (i.e., the FS link unavailability achieved in the presence of MSS interference) using the performance data generated by the *convolutional approach* analysis method, represented in Figure 4-2 above, at the link margin calculated above.

6. Compare the Post-MSS Link Unavailability data determined in #5 above with the MSS Downlink Interference Criteria determined in #4 above.

Analog Links The downlink aggregate noise power interference criteria for analog FS links given in section 3.2.1.2 are specified in terms of a limit on the probability that the baseband aggregate noise power threshold will be exceeded. The relationship between link margin and the baseband aggregate noise power criteria is derived in Annex I. The analog FS Link Margin associated with the aggregate noise power is the lesser of the margins determined using equation 4-11 and the following equation:

$$M_{dB} = SNR_{link,dB} - X_{dBm0} + 10Log_{10}(p_{\lim,pW0p}) - 87.5 + IRF_{dB}(f_c) \qquad 4\text{-}12$$

where $SNR_{link,dB}$ was defined previously, X_{dBm0} is the per-channel load (or average talk power) in dBm0, $p_{lim,pW0p}$ is the aggregate noise interference criteria for an analog link from Section 3.2.1.2, and IRF_{dB} is the interference reduction factor in dB generated using the procedures outlined in Annex A of TSB-10F or its successor. Equation 4-12 above is used in interpreting the performance data generated by the *convolutional approach* analysis method for analog FS links. The procedure is as follows:

1. Generate the FS link performance, represented by Figure 4-2 above, for each 4-kHz channel.

2. Generate the link margin, M_{dB} using Equation 4-12 above, for each 4-kHz channel, using the Short Term I baseband power criteria of Section 3.2.1.2 for $p_{lim,pW0p}$

3. Calculate $\max\{plot_{fc}(M_{dB,fc})\}$ over all 4-kHz channels where $plot_{fc}$ refers to the FS link performance represented by Figure 4-2 above for channel frequency fc, $M_{dB,fc}$ refers to the link margin calculated using Equation 4-12 above at channel frequency fc, and $plot_{fc}(M_{dB,fc})$ refers to the resulting FS link unavailability at $M_{dB,fc}$ for channel frequency fc.

4. Compare $\max\{plot_{fc}(M_{dB,fc})\}$ to the Short-Term I baseband power percentage criteria provided in Section 3.2.1.2, making sure to transform the "percentage" criteria to "decimal" criteria for a direct comparison.

5. Repeat #2 through #4 above for the Short-Term II and Long-Term baseband power criteria of Section 3.2.1.2.

4.2.2 Aggregate Noise Power: Monte Carlo Approach

Sharing between MSS and FS systems involves two primary time-varying phenomena. The first phenomenon is the space-based MSS interference geometry (which affects the MSS interference power at the FS receiver), and the second is multi-path fading along the propagation path (which affects the FS received signal level at the FS receiver). In the *convolutional approach* analysis method, the first of these two phenomena is treated via simulation while the second phenomenon is treated analytically. In the *Monte Carlo approach* analysis method, both phenomena are treated via simulation. The outputs generated by using the *Monte Carlo approach* analysis method in evaluating FS link performance in the presence of MSS downlink interference on an "aggregate noise" basis generally have the form of C/N and C/(N+I) statistics presented as an exceedence function. This section describes the steps that comprise the *Monte Carlo approach* analysis method, which uses simulation to evaluate FS link performance in the presence of MSS downlink interference on an aggregate noise (per-hop) basis.

The computer simulation described below is one particular implementation of the performance degradation methodology. Collectively, all steps must be performed, but separate programs can be used to calculate the final distribution curves.

4.2.2.1 Step 1: Calculate the Total Equivalent Noise Power (N)

The thermal noise at each FS receive station can be calculated from knowledge of the FS system noise temperature taking into account the receiver noise figure, the feed losses and the antenna noise temperature. The receiver noise temperature is given by:

$$T_{eq} = NF * T_o \qquad (K)$$

where:

NF is the noise figure (not in dB)
T_o is 290 Kelvin.

The total equivalent noise power in the receiver bandwidth is given by:

$$N_{eq} = -228.6 + 10 \log T_{eq} + 10 \log B \qquad (dBw)$$

where B is the FS receiver bandwidth (Hz).

4.2.2.2 Step 2: Calculate the Received Carrier Level, C, at Each Time Step

At each time step, calculate the received carrier level C at each receive FS station in a multi-hop FS route with multipath fading taken into account on that particular hop.

$$C = \frac{P_t \cdot G_t \cdot G_r}{L_p \cdot F_{mp} \cdot FL}$$

where:

C	=	carrier power (Watts)
P_t	=	transmit power input to the antenna (Watts)
G_t	=	gain of the transmit antenna (Unitless)
L_p	=	free space path loss (Unitless)
F_{mp}	=	instantaneous multi-path fading factor (Unitless)

G_r = gain of the receive antenna (Unitless)
FL = line loss (Unitless)

a) The received carrier level C at each station is calculated from the associated transmit FS station EIRP, the free space loss corresponding to the particular path length, multipath fading propagation loss applicable to that particular hop, the receive FS antenna gain and receive FS feed losses.

b) Multipath fading is taken into account using a random fade depth predictor whose output is consistent with the multipath fading model described in Annex A. A random fade predictor generates fade depths at each relevant time step in the simulation, such that the statistical distribution of fades generated is consistent with the multipath fading model. The time step specified for the fade depth predictor can in general be different from the time step required for generating the interference PDF, since the latter involves more slowly varying parameter values.

4.2.2.3 Step 3: Calculate the Aggregate Interfering Signal Power, I_k, into each FS Hop

At each time step, calculate the aggregate interfering signal power into each hop within the reference bandwidth generated by the individual MSS network under consideration.

$$I_k = \sum_{i=1}^{N} \sum_{j=1}^{S} \frac{E_{ijk}}{L_{ik}} G_{MSS}(\alpha_{ijk}) G_{FS}(\theta_{ik}) \frac{1}{F_k} \frac{1}{P_{ijk}} \frac{1}{A}$$

where:

I_k	=	interference power (Watts) in the reference bandwidth, into the k_{th} fixed station;
i	=	1 of N satellites of the MSS constellation visible to the fixed station;
j	=	1 of S active spot beams on the i^{th} visible satellite;
k	=	1 of M fixed stations in a fixed route;
E_{ijk}	=	the calculated EIRP (Watts) in the FS receiver bandwidth input to the antenna for the j^{th} active spot beam in its boresight direction of the i^{th} visible satellite;
L_{ik}	=	free space loss at the given reference frequency from the i^{th} visible satellite to the k^{th} fixed station;
$G_{MSS}(\alpha_{ijk})$	=	the antenna discrimination of the j^{th} active spot beam of the i^{th} visible satellite towards the k^{th} fixed station;
$G_{FS}(\theta_{ik})$	=	the antenna gain of the k^{th} fixed station in the direction of the i^{th} visible satellite;
F_k	=	the feeder loss of the k^{th} fixed station;

P_{ijk}	=	the polarization advantage factor between the i^{th} MSS satellite and the k^{th} fixed station;
A	=	interference reduction factor due to voice activation and other time variation factors;

a) The orbital positions of the MSS satellites are predicted by an orbit generator taking into account the actual or forced precession of the orbits;

b) For each MSS satellite spot beam per satellite the satellite spot beam antenna gain toward each FS station can be computed knowing the instantaneous relative position of the MSS satellite with respect to the FS station and the pointing direction of the particular satellite spot beam. The EIRP of each MSS satellite is calculated using the generic method of Annex D. The gain of each MSS satellite spot beam is characterized by the actual or predicted antenna patterns or, if unavailable, using the reference envelope radiation pattern described in Annex C;

c) For each FS station, the antenna gain towards each visible satellite is computed knowing the position of the MSS satellite with respect to the FS station and the pointing direction of the particular FS antenna. Each receive FS antenna is described by the actual or predicted antenna patterns or, if unavailable, using the reference envelope radiation pattern described in Annex B;

d) For each receive FS station, the interfering power from all MSS carriers in any spot beam of any visible MSS satellite which overlaps the FS reference bandwidth can be accumulated taking into account MSS satellite spot beam antenna discrimination, FS antenna discrimination and path loss;

e) MSS satellite systems and FS systems usually employ circular and linear polarization respectively. A polarization advantage is applied when the MSS spot beam pointing vector is within the main-lobe region of the FS antenna (see Annex B).

4.2.2.4 Step 4: Generate C/N and C/(N+I_k) at Each Time Step at the FS Receive Station

Steps 2 and 3 are repeated for each time step[10] over a statistically valid period[11] consistent with a full or equivalent orbital cycle period of the MSS satellite constellation and a representative period for

[10] The time step chosen for the interference assessment should be sufficiently small to allow for multiple samples of MSS satellite visibility within the main-beam of the particular FS stations to be considered. The selection of appropriate time step is a function of the orbital parameters of the MSS satellite constellation, the location of the FS stations and the FS antenna beamwidths.

[11] The simulation period should be sufficiently long to allow for a complete cycle period of the MSS satellite to be considered. For consideration of the effects of the uniformity of interference from a MSS satellite constellation in a month, the guidance of Annex 5 to Recommendation ITU-R F.1108 may be useful. Taking these factors into account, for MSS satellite constellations which exhibit a relatively slow orbital precession, it may be preferable to

multipath fading behavior. One method to check for statistical validity is to ensure that the results are not significantly influenced by the addition of more time steps.

4.2.2.5 Step 5: Generate the Cumulative Distribution Function (CDF) of C/(N+I)

Using the data generated in steps 1 through 5, generate the Cumulative Distribution Function (CDF) of C/(N+I). The result is a performance plot in which the x-axis represents the range of RF C/(N+I) values at the FS receiver, in dB, and the y-axis represents the probability that the received RF C/(N+I) is less than the corresponding value on the x-axis. A representative performance plot is shown in Figure 4-3.

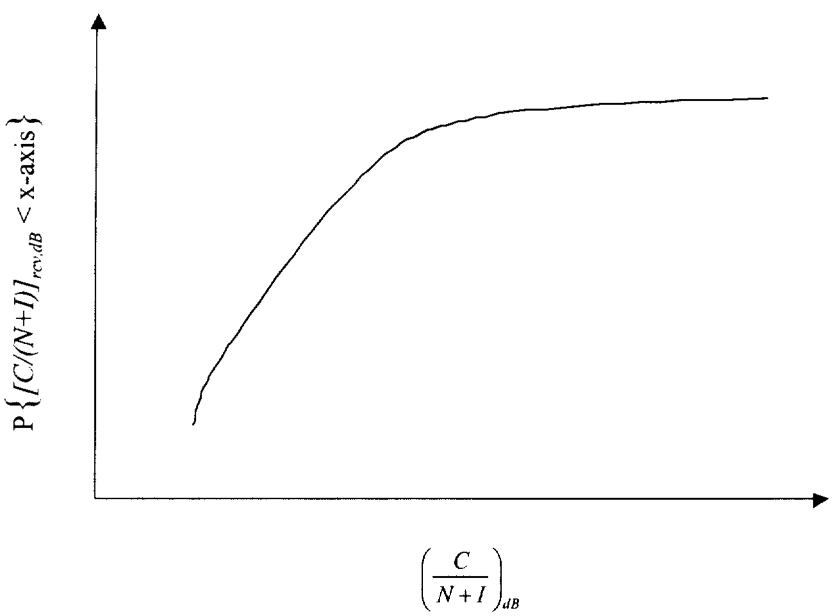

Figure 4-3: Representative Plot Depicting the Cumulative Distribution Function of the Received RF C/(N+I) in dB

4.2.2.6 Step 6: Interpret the Performance Results Within the Context of the MSS Downlink Interference Criteria of Section 3

As stated above, the performance data generated using the *Monte Carlo approach* analysis method is a plot of the cumulative distribution function for the RF C/(N+I) at the FS receiver. The MSS downlink interference criteria provided in Section 3 are given in terms of unavailability limits for digital links and

establish a forced precession rate to allow for simulation of the complete cycle period within a reasonable elapsed simulation time.

baseband noise power criteria for analog links. Thus, the method for interpreting the above performance results is different depending upon the type of FS link being evaluated. The following sections separately address the specific procedure to be applied in interpreting the performance data generated by the *Monte Carlo approach* for digital and analog FS links, respectively.

Digital Links - The procedure for interpreting the performance data generated by the *Monte Carlo Approach* analysis method for digital links is as follows:

1. Determine the theoretical C/N, in dB, required to achieve a bit error rate (BER) of 10^{-6} using the data from Annex B of TSB-10F and based on the type of modulation used by the affected FS path.

2. Calculate the Link Margin in dB:

$$M_{dB} = RSL_{dBm} - RCVR\ Threshold_{dBm}$$

   where RSL_{dBm} is the theoretical received signal level at the input to the FS receiver in dBm and $RCVR\ Threshold_{dBm}$ is the FS receiver threshold value in dBm

3. Determine the Pre-MSS Link Unavailability (i.e., the FS link unavailability achieved without MSS interference) using the appropriate FS system parameter data and the methodology presented in ITU-R P.530, or by applying the techniques described in Annex A of this document, to address multi-path fading along the FS propagation path.

4. Determine the MSS interference criteria region (i.e., *Simple Unavailability Region* or *Performance Degradation Region* from Figure 3-3 in Section 3.2.2) using the Pre-MSS Link Unavailability and Link Margin calculated above, along with the *Simple Unavailability Limit* and the *Performance Degradation Limit* provided in Section 3.2.2.

5. Determine the MSS Downlink Interference Criteria using the results from #3 above along with Figure 3-3 of Section 3.2.2.

6. Determine the Post-MSS Link Unavailability (i.e., the FS link unavailability achieved in the presence of MSS interference) using the CDF plot of the received RF C/(N+I) generated by applying the *Monte Carlo approach* analysis method, represented in Figure 4-3 above, at the theoretical C/N determined in #1 above.

7. Compare the Post-MSS Link Unavailability data determined in #6 above with the MSS Downlink Interference Criteria determined in #5 above.

Analog Links - The MSS downlink aggregate noise power interference criteria for analog links given in section 3.2.1.2 are given in terms of a limit on the probability that the baseband aggregate noise power limit is exceeded. As stated above, the data generated using the *Monte Carlo approach* analysis method is in the form of the received RF C/(N+I) in dB. Thus, an expression that provides a limit for the received RF C/(N+I) at the FS receiver in terms of the baseband aggregate noise interference limits provided in Section 3.2.1.2 is needed to interpret the *Monte Carlo* performance results for analog FM-FDM links. This expression is derived in Annex J and is repeated below:

$$\left(\frac{C}{N+I}\right)_{\lim, dB} = X_{dBm0} \quad IRF_{dB}(f_c) + 87.5 \quad 10Log(p_{\lim, pWop})$$

where X_{dBm0} is the per-channel load (or average talk power) in dBm0, $p_{lim,pW0p}$ is the aggregate noise power interference criteria for an analog link from Section 3.2.1.2, and IRF_{dB} is the interference reduction factor, in dB, generated using the procedures outlined in Annex A of TSB-10F. The equation above is used in interpreting the performance data generated by the *Monte Carlo approach* analysis method for analog FS links. The procedure is as follows:

1. Generate the FS link performance, represented by Figure 4-3 above, for the worst case 4-kHz channel.

2. Generate the C/(N+I) criteria , using the equation above, for the worst case 4-kHz channel, and using the Short Term I baseband noise power criteria of Section 3.2.1.2 for $p_{lim,pW0p}$

3. Using the CDF plot generated as a result of applying the *Monte Carlo approach* analysis method, determine the probability that the C/(N+I) criteria calculated in #2 above is not met.

4. Compare this probability to the Short Term I baseband power percentage criteria provided in Section 3.2.1.2, making sure to transform the "percentage" criteria to "decimal" criteria for a direct comparison.

5. Repeat #2 through #4 above for the Short Term II and Long Term baseband noise power criteria of Section 3.2.1.2.

4.2.3 MSS-Only Interference Noise Power

The MSS-Only interference calculation (Stage 1 or 2) is intended to be performed for *analog* FS systems as a preliminary, simplified calculation step in order to eliminate, if possible, non-problematic cases from further consideration using more detailed analyses (the *Convolution* or *Monte Carlo* approaches). While this approach is nearly identical to the international system-specific methodology (refer to Recommendation ITU-R IS.1143, Annex 1), the JWG has tested the approach using US-based software and added another set of steps to evaluate the MSS interference in terms of the equivalent baseband noise power (per hop). A simple calculation method is given below; it is based on converting the MSS RF interference power into baseband noise power--through the standard FM equation. This makes the simplifying assumption that the MSS interference spectrum is "noise-like." It has been shown that this method is conservative compared to the aggregate noise power calculation method.

The input to the calculation is the PDF of MSS radio-frequency interference power at the FS receiver input. For non-GSO MSS systems this has to be generated through simulation. The RF interference power is then converted to baseband noise power using equation 4-13.

$$\frac{s}{n_i} = \left(\frac{\Delta f_r}{f_{\max}}\right)^2 \frac{p \cdot w \cdot B}{b} \cdot \frac{c}{i} \tag{4-13}$$

where:

s is the baseband signal power, equal to 1 mW;
n_i is the baseband interference noise power;
Δf_r is the per channel RMS frequency deviation of the FS signal, given by Table 4-1;
f_{max} is the highest baseband channel frequency of the FS system, given by Table 4-1;
p is an improvement factor due to pre- and de-emphasis (if no emphasis is used this is equal to 1);
w is a psophometric weighting factor, equal to 1.8 (2.5 dB);
B is the FS RF bandwidth, given in Table 4-1;
b is the bandwidth of one telephone channel, equal to 3100 Hz;
c is the nominal received FS carrier power in W;
i is the RF interference power of the MSS system in the FS RF bandwidth, in W.

Table 4-1: Characteristics of typical FDM/FM FS receivers (from TSB-10F)

Number of channels	Per channel RMS frequency deviation (kHz)	Highest channel frequency (kHz)	RF bandwidth (Hz)
96	47	408	1,600,000
48	26	204	800,000
24	13	108	400,000

The MSS baseband interference noise power is thus calculated as

$$n_i = \frac{s \cdot b \cdot i}{p \cdot w \cdot B \cdot c}\left(\frac{f_{\max}}{\Delta f_r}\right)^2 = 1.74 \cdot 10^{12} \cdot \left(\frac{f_{\max}}{\Delta f_r}\right)^2 \frac{i}{p \cdot B \cdot c} \tag{4-14}$$

where n is given in pW0p.

The results should be compared to the criteria given in section 3.2.1.1.

4.3 Comparison of Results with Criteria

Finally, in the comparison area (Figures 4-1a and 4-1b), the FS link performance data calculated above is compared to the MSS/FS interference criteria provided in Section 3.2 of this bulletin in order to determine whether or not a specific FS link passes the criterion.

If the FS link passes the applicable criteria, no further evaluation is required. If the FS link fails to meet the criteria and if the level of fidelity and/or accuracy of the system operational model can be improved to better represent actual operations, the system operational model should be modified and the analysis redone. At this stage, more detailed interference analysis must be undertaken which necessitates a departure from the generic model approach. In general, the additional assumptions used in the interference analysis will be agreed upon between the concerned parties.

a) In some cases, FS hops may not have first Fresnel Zone clearance. In such cases, it is appropriate to add an additional loss factor to the free space loss and multipath fading loss. This factor should be based on measured data, where available.

b) In cases where statistically valid measured propagation data is available for individual FS hops, this data could be used in place of the assumed propagation model on agreement between the concerned parties. It may be possible in some cases, e.g. based on measured data, to take into account diurnal and/or seasonal variations in multipath fading propagation behavior.

c) Based on predicted realistic diurnal and geographic subscriber traffic distributions and system-dependent satellite spot beam traffic allocation, the total traffic carried in each spot beam of each MSS satellite can be identified by the MSS party using proprietary or representative algorithms (see Annex D). Based on the system-dependent internal frequency reuse constraints for the MSS satellite system, the nominal frequency plan applicable to each spot beam of each MSS satellite can similarly be identified if necessary.

If the link still fails the interference criteria after all reasonable modifications have been made to characterize actual MSS and FS operations, then further discussions between the FS and MSS system operators will be required.

5. Candidate Approach for Assessing Interference from Fixed Service Transmitters to Mobile Satellite Service User Terminals

5.1 Introduction

MSS operators may seek coordination of frequency assignments for receiving mobile earth stations (MES) operating in or near US territories with respect to US FS transmitters. Internationally, under RR No. S9.11A, this coordination may be requested when the coordination area around the MES service area (calculated in accordance with RR Appendix S7) extends into US territory. This section summarizes an approach that, if mutually agreed upon, may be used for evaluating the potential interference from FS stations to MES. The approach can also be considered for assessing the effectiveness of interference mitigation techniques that may be deemed necessary in the course of coordination.

5.2 Characterization of Potential Interference Modes

5.2.1 Overview

Several considerations provide the basis for a methodology for evaluating potential interference from FS stations to MES. Two types of interference from FS stations can occur. The first (mode 1) consist of an increase in the bit and frame error ratios resulting from the interfering signals present at the MES demodulator; the second (mode 2) type of interference results in receiver desensitization, signal distortion and intermodulation due to the presence of nearby, relatively powerful FS signals (including non-co-channel signals) in receiver stages prior to the demodulator (referred to as receiver spurious response). Interference occurs in either mode when the C/(N+I) level falls below certain threshold levels for sufficiently long periods of time to impact MES performance. These thresholds correspond with increases in BER and frame losses that result in subjectively unacceptable performance, which depend on the data and voice coding techniques employed by the MSS system (typically symbol interleaving using block coding, convolutional coding and voice processing tolerant of random frame losses). These thresholds should be agreed upon between the parties concerned.

5.2.2 Interference Thresholds

Typically, the MSS voice coding subsystems (vocoders) are designed to yield peak subjective voice transmission performance at BER of about 10^{-3} or somewhat lower, and no improvement in voice transmission quality is achieved at lower BER. As the BER is increased from about 10^{-3} the voice transmission quality typically decreases and reaches a minimum acceptable level of performance at a sustained BER of the order of 1.5×10^{-1}. At this point, the voice frame error rate is too high to permit suitable interpolation over unrecoverable frames. Each voice or data frame generally has a header that enables instant receiver recovery after reception of a corrupted data frame. This robust performance capability generally is deemed necessary because of inherent MSS signal propagation vagaries, which include rapidly varying multipath, shadowing, blockage, depolarization, and Doppler effects. Hence, MESs are very tolerant of interfering signals from FS stations, which also vary substantially. There inherently is a small probability of receiving a near-peak interfering signal level at the same instant in time that the MSS signal is severely faded, and so, satisfactory MSS performance can be achieved during transmission sessions when the average C/(N+I) is very low (e.g., typically substantially less than 10 dB). The specific thresholds to be applied in consideration of interference mode 1 (interfering signals at the demodulator) must be specified by the MSS operator seeking coordination based on the MSS system design and the agreed upon MSS performance objectives.

For co-channel interfering signals, mode 1 interference occurs at much higher C/(N+I) levels than does mode 2 interference (receiver spurious response); hence, mode 2 can be ignored for co-channel sharing situations. However, in order to enable flexible coordination and assignment of frequencies throughout the MSS allocation, MES generally will have a tuning range of at least 2170-2200 MHz. Consequently, the RF and IF filtering at the MES receiver front-end will not attenuate FS signals falling in band segments that are not actually used by the MSS system, and strong FS signals from transmitters in close proximity to the MES can overload MES receiver front-end components. This can result in receiver desensitization (e.g., automatic gain control erroneously reduces IF gain), intermodulation or saturation (normally linear amplification becomes non-linear). The occurrence of these effects is mainly dependent on the dynamic range of the MES receiver, improvement of which is generally costly. For example, assuming a dynamic range of 80 dB with respect to a 6-dB nominal signal-to-noise power ratio, the MES receiver will not suffer mode 2 interference unless the C/(N+I) (or C/I) is lower than -74 dB, in which case the FS interfering signal power would have to be of the order of 84 dB greater than the co-channel interfering signal level causing unacceptable increases in BER and frame errors.

5.2.3 Interfering and Desired Signal Propagation Considerations

Various models are used to characterize the propagation effects on desired MSS signals, including Rayleigh fading (e.g., when there is no unobstructed line-of-sight path) and log-normal fading (e.g., during shadowing from trees), which convey temporal variability for a specific MES operating environment (e.g., see Recommendations ITU-R P.680-2, P.681-3, and P.682-1 for applicable models). These models convey general effects encountered in an MES operating area, but there generally are additional local degradation effects, such a head-blockage of the desired signal. The latter local effects sometimes are controllable by the MES user (e.g., by avoiding a certain head orientation that yields high attenuation from head blockage). Because the temporal variability of the desired signal is highly dependent on the general and local MES operating environment, it is necessary to consider spatial variability of propagation phenomena in addition to temporal variability. Likewise, the interfering signals from FS stations are subject to similar propagation phenomena, such that their temporal as well as general and local spatial variabilities must be considered (i.e., tri-variate statistics).

5.3 Potential Basis for a Methodology

Further review and development of the following analysis approach is needed to establish a complete methodology for evaluating potential interference from FS transmitters to land-based mobile earth stations (MESs). The following information is suggested for consideration when developing an approach to be used for coordination in the subject frequency-sharing situation.

5.3.1 Application of Area-Indexed Interference Probabilities

In order to make this potential interference situation analytically tractable, the general and local spatial variables can be bounded by considering specific operating areas for MES. This practice has the benefit of also enabling consideration of specific FS transmitters that may interfere with MES. Specifically, the entire MES operating area can be considered as a collection of different operating environments that are distinguished by the applicable propagation models for desired and interfering signals, such that within each type of area the temporal effects and spatial effects can be evaluated. The deployment of FS stations in the overall band of concern (i.e., the tuning range of the MES plus guard-bands) and their characteristics can then be considered in an assessment of the probability of interference in each area. This task can be simplified by addressing typical areas having substantially different FS station deployments and desired and interfering signal propagation characteristics, then applying the results to other similarly defined areas.

As in the case of potential interference to FS stations from MSS satellite downlinks, it is helpful to perform relatively simple analyses first in order to dismiss cases that will not be problematic and do not warrant further, detailed analysis. This can be accomplished by first applying simple propagation models to identify two areas around an FS station in which interference might exceed acceptable levels (potentially affected operating areas): one area for mode 1 interference and another, much smaller, area for mode 2 interference. These areas could be determined assuming that the desired signal power is at the level exceeded most of the time (e.g., 80th percentile) and the interfering signals propagate over smooth, spherical Earth (i.e., disregarding terrain and other attenuating features). The areas should be determined taking into account the heights of the FS station and mobile earth station antennas. Each area would be within contours corresponding to a nominal interfering signal power level that may unacceptably degrade performance (i.e., reduce the C/(N+I) level to the applicable threshold value). More detailed analyses would be performed for MES locations within these areas using more realistic propagation models (with terrain effects) for both the desired and interfering signals in order to determine the probabilities of mode 1 and mode 2 interference, which would be compared with the performance objectives of the MSS system.

5.3.2 Potentially Affected MES Operating Areas

Using a relatively simple propagation analysis methodology, it is straightforward to determine the magnitude of the mode 1 and mode 2 potentially affected areas in which an MES might be impaired by local fixed service operations. The radial distances from the FS station that define this contour can be calculated as follows:

$$I(\text{mode}) = G_t + P_t + G_r - L_b(d) - B \qquad (5\text{-}1)$$

where:

I(mode) = interfering signal power threshold (dBW) for the mode of potential interference being considered;

G_t = transmitting antenna gain (dBi) of the FS station in the azimuth being considered;

P_t = antenna input power (dBW) of the FS station (for the carrier falling within the MES receiver necessary (channel) bandwidth;

G_r = receiving antenna gain (dBi) of the MES in the direction of the FS station, excluding local effects such as head blockage;

$L_b(d)$ = basic transmission loss (dB) predicted by a smooth Earth model (e.g., Recommendation ITU-R P.526) at a distance d;

B = ratio of FS signal bandwidth to the applicable MES receiver bandwidth (dB), using the MES receiver necessary (channel) bandwidth for interference mode 1 and the RF bandwidth for interference mode 2.

To determine the distances "d" corresponding to the contour for the interference mode under consideration, Equation 5-1 generally must be applied iteratively for various distances until the distance yielding the I(mode) threshold is found. This is because Equation 5-1 cannot generally be arranged to yield a direct solution for distance (due to the smooth Earth propagation model).

5.3.3 Assessment of Probability of Interference

The probabilities of mode 1 and mode 2 interference within a given potentially affected area of MES operation should be determined using suitable, detailed models for the propagation of desired and interfering signals. These models must take account of FS and MES antenna heights, as well as natural and man-made terrain features and foliage; however, local propagation phenomena should be initially disregarded. This can be accomplished for each potential mode of interference as follows:

A) Establish a grid of MES locations within the potentially affected area of operation, the resolution of which should be commensurate with the general spatial variabilities of desired and interfering signals;

B) Calculate the cumulative time distribution of C/(N+I) for each grid point, and identify the C/(N+I) level exceeded for the percentage of time associated with the temporal element of the MES performance objective;

C) Construct contours around contiguous grid points at which the temporal C/(N+I) threshold is not exceeded;

D) The areas within the above contours are the maximum size areas in which, depending on head blockage and other local propagation impairments, interference might exceed acceptable levels. Assessment of local propagation effects will be highly dependent upon the specific design of the MES (e.g., antenna clearance), and appropriate evaluation methodologies must be determined during coordination on a case-by-case basis.

The areas of potential interference identified above will not be defined by simple contours because the interfering signal is not attenuated monotonically with increasing distance. For example, terrain and foliage may sufficiently attenuate interfering signals at sites near an FS transmitter station, but not at more distant MES locations having higher terrain elevations.

6. Examples of Estimating Interference Between Fixed-Service Systems and Mobile-Satellite Service Systems

This section presents two examples that apply the methodologies of Section 4 to representative system scenarios. It should be noted that the examples in this section are not meant to predict the performance results of any particular system and should not be interpreted as such. The *convolutional approach* analysis method described in Section 4.2.1 was used to generate the performance results provided in this section. In example A, the maximum MSS EIRP and the theoretical received signal level (RSL) at the input to the FS receiver were chosen so as to yield a potentially small impact to FS performance due to the presence of MSS interference. In example B, these two values were changed so as to yield a more substantial impact on FS performance due to the presence of MSS interference.

6.1 Example A

The FS system parameters used in this example are shown in Table 6-1. The FS path used was a digital path having an azimuth angle of 90.2°. The path length was 9.27 km and 6-ft antennas were used. The noise floor at the input of the receiver was -135.1 dBW and the theoretical received signal level (RSL) at the input to the receiver was -33.7 dBm. The equipment used had a receiver threshold of -78.1 dBm. Note that these FS system characteristics indicate a "pre-MSS interference" fade margin of –33.7 dBm minus (–78.1 dBm) = +44.4 dB, which is representative of a fairly high margin FS path. In this example ATPC and receive antenna diversity were <u>*not*</u> used by the FS system.

The MSS system parameters used in Example A are shown in Table 6-2. A ten-satellite non-GSO system was modeled, with two orbit planes, each plane containing five satellites having circular orbits with an altitude of 10,355 km. The inclination angle is 45°. For simplicity, an omni-directional (isotropic) satellite antenna pattern was used and a constant transmit power model was used at a maximum EIRP of 34.2 dBW. A simulation of the 10 non-GSO MSS satellites was performed over a 24-hour period with a time step of one minute.

The PDF of the MSS interference power at the FS receiver, I, was generated and the results are shown in Figure 6-1. The PDF transformation described in Annex G was used to generate the PDF of the variable I", which is shown in Figure 6-2.

The PDF of I" was used in applying the *convolutional approach* analysis method to generate the performance results provided in Figure 6-3. Figure 6-3 includes the performance data both with and without MSS interference power. This corresponds to steps 1 and 3 of the *convolutional approach* analysis method. As shown in Figure 6-2, the calculated unavailability for the FS path without MSS interference was 2.57×10^{-9}. When MSS interference is present, the FS path unavailability degrades to 3.29×10^{-9}. These two performance results would then be compared with the appropriate criteria in Section 3, using the procedure outlined in step 4 of Section 4.2.1.4, in order to determine whether or not the MSS system in question meets the MSS downlink interference criteria limits (for digital links).

6.2 Example B

The only differences regarding the FS and MSS system parameters used in Example B relative to Example A were: a large reduction in the theoretical received signal level (due to increased path length), from -33.7 dBm to -60.1 dBm, yielding a "pre-MSS interference" fade margin of –60.1 dBm minus (-78.1 dBm) = +18 dB, representative of a very low margin FS path; and a substantial increase in the maximum MSS EIRP from 34.3 dBW to 45 dBW. As stated previously, these two parameters were chosen for Example A so as to result in a potentially small impact to FS performance due to the presence of MSS interference. In contrast, the impact due to MSS interference in example B is quite strong due to much lower FS link margin and higher MSS downlink EIRP.

Using the FS and MSS system parameters of Tables 6-1 and 6-2, along with the two modifications identified above for the theoretical FS received signal level and the maximum MSS EIRP, the PDF of the MSS interference power, I, at the FS receiver was generated with the results shown in Figure 6-4. The PDF transformation described in Annex G was used to generate the PDF of the variable I", which is shown in Figure 6-5.

The PDF of I" was used in applying the *convolutional approach* analysis method to generate the performance results provided in Figure 6-6. Figure 6-6 includes the performance data both with and without MSS interference power. As shown in Figure 6-6, the calculated unavailability for the FS path without MSS interference was $1.3\text{x}10^{-6}$. When MSS interference is present for the Example B scenario, the FS path unavailability is impacted considerably more strongly than Example A -- it is degraded to a link unavailability of $1.9\text{x}10^{-4}$. These two performance results would then be compared with the appropriate criteria in Section 3, using the procedure outlined in step 4 of Section 4.2.1.4 (for digital links) in order to determine whether or not the MSS system in question met the MSS downlink interference criteria limits.